Comparison of Productivity and Cost of Four Balanced Harvest Systems

Authors: Martin Strandgard, Rick Mitchell, John Wiedemann
Background

• Australia has ~900,000ha of eucalypt plantations, most of which are short rotation (~10 years) *Eucalyptus globulus* plantations producing export woodchips

• Four main harvest systems are used to harvest *Eucalyptus globulus* plantations
  • Cut-to-length at the stump
  • Cut-to-length at roadside
  • Infield chipping with a debarker/delimber/chipper
  • Infield chipping with a separate flail and chipper

• A research trial was conducted to compare the harvest systems in terms of:
  • Productivity
  • Costs
  • Other pros and cons
Site location
### Stand and site attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at harvest (years)</td>
<td>10.5</td>
</tr>
<tr>
<td>Mean height (m)</td>
<td>17.5</td>
</tr>
<tr>
<td>Mean diameter at breast height over bark (DBHOB) (mm)</td>
<td>178</td>
</tr>
<tr>
<td>Mean stem weight (GMt)</td>
<td>0.21</td>
</tr>
<tr>
<td>Stocking (stems per hectare)</td>
<td>750</td>
</tr>
<tr>
<td>Soil</td>
<td>Duplex sandy gravel</td>
</tr>
<tr>
<td>Slope (degrees)</td>
<td>&lt;5</td>
</tr>
</tbody>
</table>
Methodology

• Each harvest system was studied when harvesting in two non-adjacent three row swathes approximately 12 m by 500 m (total area ~ 6ha)

• Machine productivity was determined using time and motion studies
  • Tree weight was calculated from height and diameter
  • Trees were painted with coloured bands to identify their diameter class
  • Log weight was determined from forwarder grapple scales and truck scales

• Study was conducted over a 9 day period
Advantages/disadvantages of study approach

Advantages

• Harvest systems are compared under the same site, weather and stand conditions
• Results are obtained rapidly

Disadvantages

• Systems may be unbalanced and have unrealistic utilization rates
• Operator differences
• Machine performance differences between machines of the same type
• Generalising results to other areas
Balancing

• Harvest systems as tested were not balanced, i.e. shift-level machine productivities within a harvest system were not equal.

• Balancing was mainly done by adjusting machine utilisation rates. Where possible, utilisation rates were kept between 60–80%

• In several harvest systems, additional machines were added to achieve balance
Harvest systems – machine numbers

Cut to length at the stump
- Tracked harvester: x3
- Forwarder: x2

Cut to length at roadside
- Tracked feller buncher: x3
- Skidder: x2
- Tracked harvester: x2
- Loader: x2

Infield chip with DDC
- Tracked feller buncher
- Skidder

Infield chip with separate flail & chipper
- Tracked feller buncher
- Skidder: x2
- Chipper

usc.edu.au/firc
## Machine utilization rates (%) & productivity (GMt/PMH₀)

### Cut to length at the stump
- **Tracked harvester**
  - 69% (16 GMT/PMH₀)
- **Forwarder**
  - 74% (31 GMT/PMH₀)

### Cut to length at roadside
- **Tracked feller buncher**
  - 50% (87 GMT/PMH₀)
- **Skidder**
  - 73% (59 GMT/PMH₀)
- **Tracked harvester**
  - 59% (24 GMT/PMH₀)
- **Loader**
  - 65% (67 GMT/PMH₀)

### Infield chip with DDC
- **Tracked feller buncher**
  - 48% (62 GMT/PMH₀)
- **Skidder**
  - 76% (39 GMT/PMH₀)

### Infield chip with separate flail & chipper
- **Tracked feller buncher**
  - 42% (97 GMT/PMH₀)
- **Skidder**
  - 70% (29 GMT/PMH₀)
## Results

<table>
<thead>
<tr>
<th>Harvest system</th>
<th>Productivity (GMt/shift)</th>
<th>Harvest system cost (A$/GMt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cut to length at the stump</td>
<td>320</td>
<td>$34</td>
</tr>
<tr>
<td>Cut to length at roadside</td>
<td>431</td>
<td>$31</td>
</tr>
<tr>
<td>Infield chip with DDC</td>
<td>296</td>
<td>$29</td>
</tr>
<tr>
<td>Infield chip with separate flail &amp; chipper</td>
<td>406</td>
<td>$27</td>
</tr>
</tbody>
</table>

[usc.edu.au/firc]
Harvest system pros and cons

- Cut to length at the stump

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly flexible</td>
<td>Most expensive system</td>
</tr>
<tr>
<td>• Can add/subtract machines</td>
<td></td>
</tr>
<tr>
<td>• Can be used in sawlog operations</td>
<td></td>
</tr>
<tr>
<td>Logging residue distributed over site</td>
<td>Requires static chipper</td>
</tr>
<tr>
<td>Low machinery impact on site</td>
<td></td>
</tr>
<tr>
<td>Cold deck – logs can be stored at roadside when trucks are not available</td>
<td></td>
</tr>
<tr>
<td>Minimum crew size for a harvest system</td>
<td></td>
</tr>
</tbody>
</table>
Harvest system pros and cons

- Cut to length at roadside

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly flexible</td>
<td>More expensive than infield chipping systems</td>
</tr>
<tr>
<td>• Can add/subtract machines</td>
<td></td>
</tr>
<tr>
<td>• Can be used in sawlog operations</td>
<td></td>
</tr>
<tr>
<td>Logging residue left at roadside</td>
<td>Logging residue left at roadside</td>
</tr>
<tr>
<td>Cold deck – logs can be stored at roadside when trucks are not available</td>
<td>Higher machinery impact on site</td>
</tr>
<tr>
<td></td>
<td>Requires static chipper</td>
</tr>
</tbody>
</table>
Harvest system pros and cons

- Infield chipping systems

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheaper than systems producing logs</td>
<td>Relatively inflexible due to the chipper cost</td>
</tr>
<tr>
<td>Logging residue redistributed on site by the skidder</td>
<td>Hot deck. Chipper only operates when trucks are available</td>
</tr>
<tr>
<td>Logging residue can be left at roadside</td>
<td>Higher machinery impact on the site</td>
</tr>
</tbody>
</table>
Conclusions

• Infield chipping systems were:
  • Cheapest of the systems tested
  • Least flexible

• Cut-to-length harvest systems were:
  • Most expensive of the systems tested
  • Most flexible

(Note that these findings only apply for the study conditions)
Published papers


Thank-you!